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Interpreting Procyclical Productivity: Evidence from a Cross-Nation Cross-Industry Panel*

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We use an international panel data set of value added by industry to see if labor productivity is procyclical in response to demand shocks. It is: holding fixed our proxy for supply-side factors—the value added levels of an industry in other nations—industry-level productivity rises when value added in the rest of manufacturing rises.

Moreover, increases in unemployment are associated with a lowered degree of procyclicality in the U.S. and with heightened procyclicality in Europe. This suggests that procyclical productivity arises primarily from "labor hoarding" by firms in the U.S. that wish to avoid future training costs and primarily from "job hoarding" by workers in Europe who wish to avoid unemployment.

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I. Introduction

Labor productivity is procyclical, rising in business expansions and falling in recessions (see Hultgren, 1960; Okun, 1962). A standard view of procyclical productivity sees it as a consequence, not a cause of changes in activity. Labor productivity falls when output falls because firms retain more workers than required to produce low current output. They do this to avoid the costs of laying workers off now and hiring replacements when activity recovers.[1] Procyclical productivity does not cause but results from business cycles, because firms "value the match" with their employees.[2]

This account has recently been challenged by real business cycle theories. Such theories assert that shocks driving the business cycle are not shocks to demand, but are instead technology-driven shocks to productivity in particular industries (for example, Kydland and Prescott, 1982; Long and Plosser, 1983). Such industry-specific technology shocks directly cause an increase in production in the affected industry. They cause increased production in other industries by (i) increasing the wealth of consumers, (ii) increasing demand for intermediate inputs used in the directly affected industry, and (iii) increasing demand for (gross) complements of the output of the directly affected industry.

Such theories have been criticized on the grounds that they cannot account for correlations in *productivity* (Summers, 1986) though they might account for correlations in *output* across industries. Demand spillovers from positive technology shocks in one industry should lead to reduced labor productivity in other industries.[3] But production and productivity are positively correlated across industries. Some have made the assumption that supply-side shocks are industry-specific while demand shocks are aggregate. They have regressed productivity in an industry on total productivity or production to show that demand shifts—not shifts in supply—underlies procyclical productivity.[4]

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[1]See Holt *et al.* (1960), Oi (1962), and Okun (1962).
[2]This literature is reviewed by Fair (1969), Hamermesh (1976), and Nickel (1986).
[3]Under the assumption that the short run marginal product of labor is decreasing.
[4]See Hall (1986); Domowitz, Hubbard, and Petersen (1988); Caballero and Lyons (1989 and 1990); and Shapiro (1987). These studies place the measured Solow residual on the left hand side of their equations, while we focus on labor productivity.

This, however, is not a convincing refutation of supply-side theories. There are supply-side shocks that affect labor productivity in many industries at once: the oil price shocks of 1973 and 1979, for example. Such shocks generate procyclical productivity in many industries: producers shift away from the now-expensive factor of energy and use labor more intensively. A real business cycle-driven response of economies to oil shocks creates aggregate movements in productivity and output. Economists assuming that "supply" is industry-specific and "demand" aggregate would falsely interpret such movements as evidence that procyclical productivity was demand-driven.

This paper disentangles demand- and supply-driven components of procyclical productivity without making the possibly dangerous assumption that everything aggregate is demand. Cost shocks—like the oil shocks of 1973 and 1979—directly affecting productivity in many *industries* also affect many *nations*. A cross-industry cross-nation panel of data on value added by industry can be used to separate the effects of demand and supply shocks.[5]

Industrial value added shifts correlated with value added shifts in other industries in the same economy, and yet not correlated with industrial value added shifts in other nations, are candidates for the label "demand." Industrial value added shifts correlated with value added shifts in the same industry in other nations, but not correlated with value added shifts in other industries in the same country, are candidates for the label "supply." The effects of idiosyncratic national aggregate demand shocks can be determined because such shocks are both intersectoral and nation-specific.

Needless to say, we do not believe that "supply" shifts caused by technology or even changes in prices diffuse instantlyacross the nations of our sample. However, we do believe that such shifts spread over the countries in our sample within a few years. We believe it is important to control for such supply shifts before concluding that procyclical productivity is demand-driven.

We are concerned that much of the evidence on procyclical productivity is driven by relatively low-frequency changes in productivity and output growth—which was high in the 1960's, low during a period from the early 1970's to the early 1980's, and moderate through

[5]A method first used by Stockman (1988).

the mid-1980's. Such low-frequency changes might well be supply- rather than demand-driven. We do not believe that supply-side effects will be adequately removed by using instruments, for example U.S. military spending, that while not causally related to supply factors nevertheless have much of their own variance produced by low-frequency movements.

The identifying assumptions we require are relatively minor. One need not assume that technological progress is uniform across countries. One need only assume that there are no technological or other supply-side shocks that are (a) specific to a single country yet (b) affect a broad range of industries within manufacturing.[6]

We find that even after controlling for industry-specific cross-nation shocks, sectoral productivity growth remains positively correlated with aggregate manufacturing output. This suggests that increased aggregate demand leads to increased labor productivity, and that there is a component of procyclical productivity to be accounted for by an old-fashioned Keynesian "labor hoarding" story, or by some other model in which firms and workers value their match.

We go on to investigate the cross-nation pattern of procyclical productivity. If firm-side labor hoarding—due to workforce finding and training costs—is important, productivity should be more procyclical when unemployment is low.[7] When unemployment is high, laid off workers are less likely to find new jobs, are more likely to still be available when the firm wishes to recall them, and so the incentives for the firm to engage in labor hoarding are diminished.

If worker-side job hoarding—firing costs that firms bear in when workers are laid off but avoid when workers voluntarily quit—is important, then productivity should be more procyclical when unemployment is high: workers will then resist dismissals with more

[6]We use labor productivity and not total factor productivity as a dependent variable, and so our results on procyclical productivity cannot be attributed to market power. Our calculations are not affected by deviations of prices from marginal products.

[7]In the United States, labor productivity appears less procyclical in highly unionized industries (see Medoff, 1979; Freeman and Medoff, 1984). This might arise because unionized workers share rents, would be likely to suffer a cut in wages if they took jobs in non-union establishments, and so wait to be around. Thus the firm is free to lay them off temporarily when demand is momentarily slack without risking the loss of the value of the match.

determination, quits will be rare, and restrictions on layoffs may bind more when unemployment is high.[8]

If procyclical labor productivity is simply a consequence of increasing returns to scale, the procyclicality of production should be unaffected by the level of the unemployment rate.

We find that in the United States labor productivity is less procyclical when unemployment is high. In Germany and—less strongly—in Britain and in Europe as a whole, however, productivity is more procyclical when unemployment is high. There are differences between the U.S. and Europe in sign and strength of the relation between the degree of procyclicality in productivity and unemployment.

This difference suggests that demand-driven procyclical productivity may spring more from labor hoarding in the United States and more from job hoarding in Europe.[9] The dependence of the cyclical behavior of productivity in these nations on labor market conditions raises the possibility that procyclical productivity arises from national institutions that mold the dynamic relationships between workers and firms, and is not simply the result of an increasing returns to scale technology.

After this introductory section, section II describes the data used in this paper. Section III presents the evidence on the existence of procyclical productivity in response to demand shocks. Section IV correlates the degree of procyclical productivity with the unemployment rate. It leads to the tentative conclusion that "worker hoarding" by firms is relatively more important as a cause of procyclical productivity in response to demand shocks in the United States, while "job hoarding" by workers is relatively more important as a cause of procyclical productivity in response to demand shocks in Germany and perhaps in Britain. Section V concludes.

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[8]See Blanchard and Summers (1986), Bentolila and Bertola (1990), and Krugman (1988).

[9]Abraham and Houseman (1989) use a panel of ten matched U.S. and German manufacturing industries, and find that the immediate effect of a reduction in shipments on employment is much smaller than Germany. They interpret their findings as implying that German firms, because of worker "job hoarding," are less free in the short run to use layoffs to adjust unemployment. They also find that the workforce adjustment process was slower in Germany after 1972. In 1972 German legal restrictions on layoffs were significantly strengthened by the Works Constitution Act, and the post-1972 period has seen higher unemployment. Abraham and Houseman, however, are unable to control for changes in technology and costs—particularly the cost of oil—and are forced to assume that production is exogenous. Our broader panel of countries should make it possible to control for such factors to some degree.

II. An International Intersectoral Panel of Value Added by Industry

We use the OECD International Sectoral Data Bank as our primary data source (Meyer-zu-Schlochtern, 1986). Our data set contains annual data on real value added, employment, and capital by industry for fourteen OECD nations from 1960 to 1986. Since our approach requires a balanced panel and we strongly desire sample of long length, we are forced to focus on seven nations for which data on real value added are available from the 1960's onward—Belgium, Finland, France, Germany, Norway, the United Kingdom, and the United States.[10] Data are available for seven ISIC industries within the manufacturing sector: food, textiles, paper, chemicals, non-metallic minerals (i.e., stone, clay, and glass), basic metal production, and mechanical equipment. Oservations are complete from 1962 to 1985.

The OECD international sectoral database includes employment by industry, but it does not include average hours worked by industry. We augment the data by multiplying employment by average hours worked in manufacturing.[11] This procedure assumes a perfect correlation between average hours worked in different industries. Thus it induces positively correlated measurement error between total hours worked in different industries.

Since hours are correlated with value added, this measurement error induces a negative correlation between value added per man-hour in one industry and in another. The use of average hours in manufacturing, instead of average hours in each industry, biases the data against revealing procyclical labor productivity.[12]

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[10]Netherlands data are also available for the 1960's. Unfortunately a change in definitions in 1970 makes Dutch data from the 1960's incomparable to data from 1970 on.

[11]Unpublished data were kindly provided by Robert Gordon.

[12]An additional data problem is posed by the fact that labor productivity data are not available whenever value added data are available. Oddly, the OECD does not report total manufacturing employment in the U.S.A. before 1968. The ISIC classifications used by the OECD do not correspond exactly to SIC classifications, and so comparable data cannot be added from B.L.S. sources. The OECD does, however, provide data on wage and salary employment in U.S. industries for the 1960's. Fitted values from a regression of total employment on wage and salary employment were therefore used as a proxy for total employment. The R^2 of these regressions ranges from 99.5% to 99.9%. We conclude that it is unlikely that this neglect of the self-employed induces significant biases.

We do not possess data on average hours worked in Finland. Reported average hours worked can be found in the I.L.O.'s *Labor Statistics Yearbook*, but reported average hours from this source show a large increase from 38.5 hours per week in 1978 to 41 hours per week in 1979. This shift is large relative to other variation, and we believe it reflects a change in coverage. Finland, therefore, was excluded from all regressions that required average hours worked.

In addition, data on employment in basic metals and in equipment are not available for France or Belgium in the 1960's. Regressions using these industries as dependent variables therefore use data since 1970 only.

III. Procyclical Productivity and Aggregate Demand

Nation-Specific Aggregate Demand Movements

It is fruitless to try to use nation-specific movements in manufacturing value added to identify demand-driven movements in productivity unless such movements exist. Stockman (1988) has already used an international intersectoral panel to identify demand and supply-specific movements in output. Stockman assumed that all industries have the same cyclical responsiveness to shifts in aggregate demand—that, in the language of finance, all have the same β_i with respect to aggregate output—and that all countries have the same $\gamma_i$responsiveness to international supply shocks.[13] In spite of these restrictive assumptions on the form of his nation- and industry-specific components, Stockman found that 12.2 percent of variance of industry value added is accounted for by nation-specific components orthogonal to industry-specific value added movements, and that 14 percent of variance is accounted for by industry-specific components orthogonal to nation-specific output movements.

[13]Another possibly dubious assumption. For example, the United States imposed oil price controls after the 1973 oil shock, and so the real price of oil in the U.S. did not rise as much as in other nations. We would be surprised if substitution away from intensive use of energy proceeded as fast in the U.S. as in Europe after 1973.

Waldmann (1989 and 1991), using the OECD database, estimated nation and industry effects without imposing the assumption that β_i and γ_i coefficients were constant across industries. He found that orthogonal nation effects account for 17 percent of variance in real value added, while orthogonal industry effects account for only 9.5 percent of variance. He also found that orthogonal nation effects accounted for a very small fraction of the variancein real value added in small open economies such as Belgium and Finland. Results from Waldmann (1991) are reproduced as table 1.

Table 1
Share of Industry Value Added Growth Variance Accounted for by Orthogonal Country and Industry Effects

		USA	Deu	Fra	Bel	Fin	Nor	UK	Average	Ratio
Food	Country	0.030	0.198	0.183	0.072	0.152	0.048	0.338	0.101	2.267
	Industry	0.062	0.032	0.031	0.027	0.040	0.029	0.219	0.044	
Textiles	Country	0.389	0.207	0.093	0.071	0.291	0.034	0.693	0.248	5.075
	Industry	0.007	0.002	0.057	0.129	0.029	0.053	0.003	0.050	
Paper	Country	0.240	0.213	0.161	0.003	0.186	0.042	0.124	0.147	1.157
	Industry	0.021	0.049	0.011	0.177	0.288	0.137	0.108	0.127	
Chemicals	Country	0.169	0.022	0.025	0.137	0.062	0.023	0.182	0.091	0.521
	Industry	0.096	0.376	0.210	0.002	0.320	0.168	0.082	0.174	
Stone, Clay, and Glass	Country	0.589	0.112	0.038	0.048	0.312	0.052	0.257	0.214	3.456
	Industry	0.035	0.097	0.150	0.056	0.002	0.063	0.040	0.062	
Basic Metals	Country	0.258	0.095	0.099	0.076	0.021	0.004	0.279	0.126	1.266
	Industry	0.076	0.017	0.109	0.225	0.094	0.147	0.014	0.099	
Mechanical Equipment	Country	0.730	0.276	0.303	0.109	0.025	0.009	0.218	0.295	5.698
	Industry	0.038	0.039	0.020	0.106	0.002	0.121	0.063	0.095	
Average	Country	0.375	0.137	0.109	0.083	0.121	0.022	0.292	0.170	1.789
	Industry	0.056	0.118	0.097	0.099	0.130	0.118	0.049	0.095	

The divergence of the strength of nation-specific movements in manufacturing value added leads us to anticipate that our attempts to identify demand-driven procyclical productivity will have almost no power in small open economies like Belgium, Finland, and Norway. Such economies do not possess an idiosyncratic, nation-specific business cycle of their own. Moreover, the existence of large nation-specific components in value added for larger countries leads us to anticipate that our procedures will have considerable power for large countries—the polar case of the United States, and also France, Germany, and the United Kingdom—where spillovers of demand shocks are smaller, and where there is moreof a nation-specific business cycle.[14]

Initial Regressions

The growth of value added per man-hour for industry i in nation n was regressed on the growth of value added of the rest of manufacturing in nation n, and on the average growth of production per man-hour in industry i in other countries, as described in equation 1:

$$(1) \qquad \Delta\{\log(Y/N_{int})\} = c_{ni} + \beta_{ni}[\Delta\{\log(Y_{nt} - Y_{int})\}] + \gamma_{ni}[\Delta\{\log(Y/N_{i(-n)t})\}] + \varepsilon_{int}$$

where Y/N denotes value added per man-hour; subscripts i, n, and t run over industries, nations, and years, respectively; Y_{nt} refers to value added in all of manufacturing in country n in year t; Y_{nt}-Y_{int} denotes value added in manufacturing in country n in year t in all industries except industry i; and a subscript (-n) denote averages over the other countries in the sample (i.e., excluding country n) for an industry i. Results from estimating equation 1 are reported in tables 2 through 4.

Table 2 reports the β coefficients, which measure the sensitivity of industry-level value added per man hour to movements in value added in the rest of manufacturing in the same nation (holding constant value added in that particular industry in other nations). The β coefficients on the growth of manufacturing are generally positive. The precision-weighted average is positive for all nations. It ranges from 0.079 in the U.S. to 0.153 in the U.K.. Each one percent increase in value added in the other manufacturing industries in the U.S. is associated with an increase in labor productivity in each industry that averages .079 percent

[14]It would not be appropriate to draw the conclusion that aggregate demand shocks account for twice as much of the variance in the typical industry's value added growth rate as supply shocks. Undoubtedly, most of both supply- and demand-side shocks are left unidentified by our procedures. We wish only to maintain that the 17 percent of industry value added growth rate variance that is (a) correlated with changes in the rest of manufacturing production in the same country while (b) orthogonal to changes in value added in the same industry in other countries is not "supply." (Conversely, the 9.5 percent of industry value added growth rate variance that is (c) correlated with changes in value added in the same industry in other countries but (d) orthogonal to changes in the rest of manufacturing production in the same country is not "demand.")

above what would be expected, given value added growth in that particular industry in other nations. The precision-weighted average across countries of β coefficients for a given industry vary strikingly, ranging from -.006 for food products to 0.259 for non-metallic minerals. The summary precision-weighted average of all coefficients on the growth of the rest of manufacturing in the same country is 0.106.

Table 2

β Coefficients of Value Added per Man-Hour Regressed on the Growth of Manufacturing in the Same Country

	Observations	USA	Deu	Fra	Bel	Nor	UK	Average
Food	22	-0.100	-0.042	0.172	-0.033	0.363	0.024	-0.006
		(0.127)	(0.088)	(0.226)	(0.123)	(0.333)	(0.076)	(0.047)
Textiles	22	0.011	-0.093	0.338	0.249	-0.025	0.292	0.093
		(0.123)	(0.163)	(0.213)	(0.234)	(0.262)	(0.185)	(0.073)
Paper	22	0.048	0.224	0.186	-0.097	0.117	0.495	0.181
		(0.166)	(0.131)	(0.294)	(0.195)	(0.244)	(0.172)	(0.074)
Chemicals	22	0.017	0.078	-0.077	0.860	0.465	0.247	0.127
		(0.151)	(0.238)	(0.229)	(0.411)	(0.358)	(0.214)	(0.093)
Stone, Clay	22	0.201	0.290	0.479	0.393	-0.292	0.345	0.259
and Glass		(0.103)	(0.122)	(0.242)	(0.267)	(0.357)	(0.206)	(0.067)
Basic	14	0.526	-0.228	-0.346	0.091	-0.216	0.288	0.025
Metals		(0 445)	(0.440)	(0.422)	(0.345)	(0.877)	(0.651)	(0.189)
Mechanical	14	0.330	0.137	-0.130	0.169	0.113	0.147	0.142
Equipment		(0.213)	(0.113)	(0.283)	(0.273)	(0.191)	(0.191)	(0.074)
Average		0.079	0-088	0.150	0.088	0.107	0.153	0.106
		(0 055)	(0.050)	(0.096)	(0.081)	(0.109)	(0.057)	(0.027)
SUR estimate*		0.036	0.085	0.332	0.077	0.203	0.117	0.127
		(0.079)	(0.069)	(0.084)	(0.089)	(0.152)	(0.066)	(0.033)

Standard errors in parentheses.
Regressions control for average productivity growth in the same industry in other countries.
*Equation for 5 industries estimated by SUR, restricting β to be the same in each industry. Regression does not use data from basic metals or mechanical equipment..

Under the assumption that the disturbance terms for different industries are independent, standard errors for the precision-weighted averages within industries and within nations of the β coefficients were calculated and are reported in table 2. For example, the calculated standard error of the weighted average of all the β coefficients is only 0.027, giving a t-statistic of 3.92. However as is shown below this assumption is not valid. Instead, seemingly-unrelated-regressions procedures were used to test the null hypothesis that labor productivity is not procyclical when controlling for value added growth in the same industry in other countries. Data on different industries were stacked, and equation 1 was reestimated with the β coefficient restricted to be the same in different industries.[15]

Table 2 also reports seemingly-unrelated-regressions estimated coefficients on the growth of the rest of manufacturing in the same country. The coefficients are all positive and are similar to the precision weighted national average OLS estimated β coefficients. Their rank order is almost unchanged. All coefficients, save that of France, are within one standard error of the precision weighted national average coefficients. The reported standard errors are somewhat larger for the SUR estimates.[16]

The disturbances in different countries are nearly orthogonal by construction, because international averages of productivity growth in the same industry in the other countries are included in the regressions. Therefore a standard error can be calculated for the grand precision weighted average of the SUR β coefficients estimated for each nation. The grand precision-weighted average is 0.127, with a standard error of 0.033. Labor productivity thus remains procyclical after controlling for the average rates of industry productivity growth in different countries.

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[15]Unfortunately, when seemingly-unrelated-regressions is used and international averages are included the sample contains only those years in which all industries in all countries report data. The absence of data from the 1960's on employment in the basic metals and metal equipment industries in France and Belgium leaves only 5 industries in 6 countries.

[16]Since the true standard errors must be smaller, this implies that the reported standard errors of the weighted averages are understated.

Table 3
Coefficients of Value Added per Man-Hour on the Growth of the Same Industry in Other Countries

	USA	Deu	Fra	Bel	Nor	UK	Precision-Weighted Average
Food	0.278	0.282	0.694	0.647	-0.631	0.097	0 244
	(0.618)	(0.282)	(0.688)	(0.471)	(0.832)	(0.268)	(0.164)
Textiles	0.292	0.325	0.728	0.423	0.347	0.619	0.445
	(0.424)	(0.398)	(0.457)	(0.635)	(0.536)	(0.513)	(0.195)
Paper	0.744	0.667	0.039	0.331	0.946	1.086	0.637
	(0.511)	(0.275)	(0.466)	(0.406)	(0.441)	(0.449)	(0.163)
Chemicals	0.391	0.999	0.761	0.023	0.794	0.938	0.720
	(0.303)	(0.345)	(0.258)	(0.648)	(0.426)	(0.343)	(0.140)
Stone, Clay, and Glass	0.545	0.586	1.000	0.500	1.236	0.667	0.670
	(0.220)	(0.186)	(0.316)	(0.433)	(0.465)	(0.349)	(0.114)
Basic Metals	0.361	0.251	0.412	1.101	1.157	1.070	0.589
	(0.763)	(0.358)	(0.299)	(0.384)	(0.813)	(0.833)	(0.181)
Mechanical Equipment	0.163	0.466	0.426	1.323	0.154	1.208	0.470
	(0.704)	(0.231)	(0.447)	(0.828)	(0.405)	(0.678)	(0.168)
Prec.-Weighted Average	0.458	0.526	0.632	0.623	0.645	0.621	0.569
	(0.146)	(0.102)	(0.138)	(0.186)	(0.190)	(0.152)	(0.058)

Standard errors in parentheses.

Table 3 reports the estimated γ coefficients, which capture the responsiveness of productivity growth in an industry to value added growth in the same industry in other countries (holding constant value added in the rest of the manufacturing sector of that particular country). The industries that appear most sensitive to "supply" conditions, as captured by the growth of value added in the same industry in other countries, are the chemicals and the non-metallic minerals industries. The industries that appear least sensitive are the food products and textiles industries.

Table 4
Partial R^2's of Orthogonal Country and Industry Effects as Determinants of Value Added per Man-Hour Growth

		USA	Deu	Fra	Bel	Nor	UK	Average	Ratio
Food	Country	0.031	0.011	0.027	0.003	0.058	0.005	0.035	0.981
	Industry	0.010	0.050	0.098	0.090	0.028	0.007	0.036	
Textiles	Country	0.001	0.016	0.104	0.055	0.001	0.108	0.052	1.191
	Industry	0.024	0.034	0.104	0.022	0.022	0.063	0.043	
Paper	Country	0.003	0.087	0.021	0.013	0.009	0.139	0.049	0.536
	Industry	0.085	0.174	0.001	0.034	0.184	0.098	0.092	
Chemicals	Country	0.001	0.003	0.004	0.165	0.067	0.034	0.074	0.580
	Industry	0.077	0.271	0.295	0.000	0.137	0.190	0.127	
Stone, Clay and Glass	Country	0.113	0.121	0.082	0.080	0.025	0.085	0.075	0.438
	Industry	0.182	0.212	0.208	0.049	0.267	0.112	0.170	
Basic Metals	Country	0.086	0.023	0.051	0.003	0.005	0.013	0.026	0.194
	Industry	0.014	0.043	0.146	0.373	0.155	0.108	0.135	
Mechanical Equipment	Country	0.175	0.084	0.018	0.027	0.030	0.031	0.070	0.652
	Industry	0.004	0.234	0.076	0.179	0.012	0.166	0.107	
Average	Country	0.073	0.039	0.048	0.071	0.040	0.049	0.050	0.435
	Industry	0.039	0.160	0.130	0.114	0.141	0.116	0.115	
Ratio		1.872	0.244	0.369	0.623	0.284	0.422		

Table 4 shows that the fraction of the variance in productivity accounted for by orthogonal nation-specific effects is much smaller than the fraction of the variance in value added explained by orthogonal nation-specific effects in table 1. Orthogonal nation-specific effects account for 4.98 percent of variance, including the variance 'explained' for industries which have negative estimated coefficients on value added in other industries. In each country it is far lower than the partial R^2 for the regressions in Waldmann (1991), with value added as the dependent variable. Table 4 also shows that the fraction of total variance in value added per manhour explained by orthogonal industry effects is 11.5 percent, somewhat higher than the fraction of the variance of value added accounted for by orthogonal industry effects in Waldmann (1991). Since employment in different industries is highly correlated, this finding that the nation effects on labor productivity are smaller than nation effects on value added is not unexpected.

Omitted Variable Bias

The presence of significant nation effects on labor productivity would appear to be evidence in favor of labor hoarding-based, job hoarding-based, or increasing returns to scale-based interpretations of procyclical labor productivity. Increased aggregate demand causes increased labor productivity, even controlling for cost and supply shocks. But before the orthogonal nation-specific effects can be interpreted as effects of aggregate demand, more sophisticated attempts to control for supply shocks are desirable. We examined three possible sets of omitted variables.

The first avenue of approach was that perhaps the rate of productivity growth in the nations of the sample shifts over time. A linear trend was added to the regressions which—since the dependent variable is a growth rate—corresponds to allowing for quadratic trend in the level of productivity. Such a trend has almost no effect on the estimated β coefficients on national value added in the rest of manufacturing. For example, the seemingly-unrelated-regressions estimated β coefficient for the United States is 0.032 instead of 0.037, and the summary precision-weighted average of the coefficients on national manufacturing remains 0.127 (results not shown).

The second avenue was to try to control explicitly for the oil shocks of the 1970's. Controlling for average productivity growth in the same industry in different countries is to some degree a control for the effects of the oil shocks of the 1970's. But oil shocks may well have had different effects on different nation—on oil exporters such as England and Norway, for example. Since the complex pattern of effects of the oil shocks on an industry may not have been captured by a single γ coefficient, we reestimated the productivity regressions including as additional explanatory variables the change and the lagged change in the price of oil and the lagged change in the price of oil. Once again the additional regressors had little effect on the estimated β coefficients. The summary precision-weighted average of the seemingly-unrelated-regressions coefficients on national value added in the rest of manufacturing increases from 0.127 to 0.128 (results not shown).

The third avenue considered was to include estimates of the capital stock in order to examine the procyclicality not of labor productivity but of total factor productivity—the Solow residual. Up to this point the Solow residual has been neglected for three reasons. First, the data set does not contain adequate data on shares of labor and capital in pre-tax value added; second, OECD studies based on the data warn that reported factor shares are unreliable (see Meyer-zu-Schlochtern, 1988).[17] Third, Solow residuals exhibit spurious cyclicality if firms possess market power (Hall, 1986 and 1988).[18]

To investigate whether the omission of capital stock variables was biasing our results, we assumed that the elasticity of value added with respect to labor and capital was constant and imposed constant returns to scale to arrive at a Cobb-Douglas production function in which value added per man-hour is a function also of the capital/labor ratio.[19] This led to equation 2:

$$\text{(2)} \quad \Delta\{\log(Y/N_{int})\} = c_{ni} + \beta_{ni}[\Delta\{\log(Y_{nt}-Y_{int})\}] + \gamma_{ni}[\Delta\{\log(Y/N_{i(-n)t})\}] + \delta_{in}[\Delta\{\log(K_{int}/E_{int})\}] + \varepsilon_{int}$$

where K stands for the real capital stock, and E for the level of employment.[20]

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[17] In fact, such studies throw away the reported factor share data and instead arbitrarily assume that the share of labor is 75%.

[18] A corrected Solow residual could be constructed under the assumption that the ratio of price to marginal cost is constant, but there is little reason to believe this assumption (see Domowitz, Hubbard, and Petersen,1988).

[19] Data on capital stocks are not available for Finland. However, the absence of reliable average hours data for Finland makes its inclusion impossible in any event. Data on capital stocks in Norway in the 1960's also do not exist in the data set, reducing the number of countries in the sample to five.

[20] The ratio of capital per worker, rather than the ratio of capital per man-hour is used on the assumption that the work week of capital is the same as work week of workers. Under the alternative assumption that the work week of capital is fixed and thus that the appropriate capital/labor ratio is capital divided by hours worked, the estimated elasticity of value added with respect to capital is negative for most industries and most countries.

Table 5
Value Added per Man Hour Regressed on Growth of the Rest of Manufacturing, on Industry Growth in Other Countries, and on the Capital/Labor Ratio

	USA	Deu	Fra	Bel	UK		Average
β	0.247 (0.080)	0.094 (0.054)	0.193 (0.094)	0.062 (0.072)	0.174 (0.045)		
γ	0.518 (0.144)	0.428 (0.105)	0.581 (0.142)	0.781 (0.181)	0.284 (0.119)		
δ	0.245 (0.143)	0.272 (0.087)	-0.025 (0.182)	0.325 (0.144)	0.795 (0.091)		
β estimated by SUR	0.089 (0.089)	0.045 (0.074)	0.286 (0.086)	0.000 (0.075)	0.242 (0 066)		0.133 (0 034)

	Food	Textiles	Paper	Chemicals	Stone...	Metals	Equipment
β	-0.010 (0.038)	0.270 (0.088)	0.261 (0.083)	0.448 (0.107)	0.373 (0.085)	0.390 (0.161)	0.216 (0.103)
γ	0.097 (0.135)	0.421 (0.185)	0.527 (0.189)	0.665 (0.137)	0.645 (0.126)	0.608 (0.176)	0.455 (0.186)
δ	0.777 (0.110)	0.371 (0.130)	0.098 (0.171)	0.484 (0.150)	0.206 (0.109)	0.478 (0.168)	0.330 (0.162)

Standard errors in parentheses. Regressions control for average productivity growth in the eame industry in other countries.

The results of regressions including the capital/labor ratio were disappointing. Summary β, γ, and δ coefficients for nations and industries are reported in table 5. The estimated coefficients on the capital/labor ratio are often implausible: for 13 of 35 underlying regressions, the coefficient on the capital/labor ratio is negative. The precision-weighted average coefficient is negative for France; for England the average coefficient is enormous—0.795 with a standard error of 0.091.

We ascribe these disappointing results to the fact that the variance of changes in capital stocks is low, and so changes in the capital/labor ratio are nearly the negative of changes in employment.[21] This interpretation is supported by the finding of similar results when the capital/labor ratio is replaced by 1/employment (results not shown): the coefficients on 1/employment are in fact greater than the coefficients on the capital labor ratio. We conclude that the OECD estimates of capital are not useful in attempting to analyze labor productivity over the 1960's, 1970's, and 1980's.[22]

Each of the different sets of regressions run is vulnerable to criticism based on the omission of a potential supply side effect. The similarity of results that devote different degrees of effort to controlling for such effects in the specifications we have tried, together with the finding that all regressions show significant nation effects, suggests that these criticisms are not serious. The inclusion of valid supply-side variables should reduce estimated nation effects even if the supply-side variables are relatively poor proxies. This does not take place. We are confident that the estimated association of value added and productivity shows that increased demand leads to increased labor productivity.

Instrumental Variables Estimates of Procyclical Labor Productivity

An appropriate measure of the magnitude of demand-driven productivity changes in a given industry is the elasticity of hours worked with respect to value added. In table 6, we estimate this elasticity by instrumenting the demand for each industry's value added

[21] In this case, the large coefficient estimated for England perhaps reflects the fact that the capital/labor ratio is picking up the large negative disturbance to employment following the accession of Margaret Thatcher (Layard and Nickell, 1989). There was a large drop in English manufacturing employment in 1982. This huge drop in employment corresponds to a huge increse in the measured capital/ labor ratio, and to a huge increase in production per man-hour. Such an increase can be interpreted as showing that employment follows value added with a lag due to job hoarding, or that by 1983 Thatcher had finally terrorized the unions enough that she and private firms could fire workers in droves (see Bertola and Bentolila, 1987). Neither explanation has anything to do with the effect the capital/labor ratio is supposed to capture—that workers can produce more value added working with machines than without them.

[22] It is reassuring to note that the inclusion of the capital/labor ratio does not change the measured cyclicality of labor productivity enormously. Labor productivity remains procyclical controlling for growth in the same industry in other countries when the capital/labor or the 1/labor ratios are included in the regressions.

by the growth of manufacturing value added in the same country outside that industry. The estimates reflect not only long run elasticities of hours with respect to value added, but also the effects of labor or job hoarding, which should reduce the elasticity of hours worked with respect to value added.

Table 6
Elasticity of Hours Worked with Respect to Value Added, Not Controlling for Industry Effects

	USA	Deu	Fra	Bel	Nor	UK	Precision-Weighted Average
Food	1.747	1.089	0.265	1.016	0.433	0.907	0.722
	(1.562)	(0.313)	(0.346)	(0.621)	(0.289)	(0.271)	(0.133)
Textiles	0.955	1.076	0.697	0.725	1.040	0.719	0.810
	(0.159)	(0.239)	(0.158)	(0.201)	(0.514)	(0.153)	(0.075)
Paper	0.661	0.646	0.731	1.048	0.514	0.270	0.480
	(0.135)	(0.103)	(0.282)	(0.372)	(0.330)	(0.093)	(0.055)
Chemicals	0.826	0.648	0.768	0.343	0.343	0.501	0.536
	(0.172)	(0.149)	(0.161)	(0.102)	(0.189)	(0.116)	(0.055)
Stone, Clay	0.729	0.615	0.451	0.492	0.744	0.551	0.579
and Glass	(0.082)	(0.081)	(0.085)	(0.120)	(0.372)	(0.111)	(0.039)
Basic	0.561	0.702	1.128	0.553	0.982	0.519	0.574
Metals	(0.068)	(0.1661	(0.326)	(0.231)	(1.092)	(0.183)	(0.056)
Mechanical	0.729	0.704	0.109	0.678	0.394	0.529	0.692
Equipment	(0.106)	(0 073)	(0.401)	(0.311)	(0.340)	(0 167)	(0.055)
P-W Average	0.682	0.683	0.573	0.492	0.480	0.485	
	(0.041)	(0.043)	(0.063)	(0.066)	(0.119)	(0.050)	

Standard errors in parentheses.
Regressions do not include the average growth of value added or of hours worked in the same industry in different countries.

In table 6 no additional regressors are included to control for industry-specific shocks. The precision-weighted average of the estimated elasticities ranges from 0.480 for Norway to 0.683 for Germany. In Germany a one-percent increase in value added corresponds to a 0.68 percent increase in hours worked. Even for Germany, the nation with the highest value, the precision-weighted average coefficient is significantly less than one—implying that labor productivity is procyclical. The U.S. has the second highest average elasticity, noticeably greater than the elasticity estimated for any European country save Germany. The fact that total hours adjust the same amount in the United States and Germany confirms the results of Abraham and Houseman (1989).[23]

Table 7
Elasticity of Hours Worked with Respect to Value Added, Controlling for Industry Effects

	USA	Deu	Fra	Bel	Nor	UK	Precision-Weighted Average
Food	2.155	1.057	-0.016	0.365	0.534	0.607	0.181
	(3.338)	(0.518)	(0.169)	(0.591)	(0.678)	(0.440)	(0.143)
Textiles	1.036	0.892	0.406	0.674	4.334	0.552	0.634
	(0.246)	(0.306)	(0.197)	(0.364)	(13.114)	(0.145)	(0.096)
Paper	0.843	0.688	0.791	0.771	0.943	0.524	0.672
	(0.396)	(0.143)	(0.538)	(1.752)	(1.289)	(0.242)	(0.114)
Chemicals	0.859	2.481	2.145	0.199	0.344	0.428	0.360
	(0.277)	(1.748)	(1.205)	(0.130)	(0.413)	(0.244)	(0.102)
Stone, Clay, and Glass	0.705	0.764	0.966	0.312	1.440	0.420	0.653
	(0.083)	(0.162)	(0.302)	(0.225)	(1.278)	(0.162)	(0.063)
Basic Metals	0.637	-1.221	-6.438	1.098	1.873	0.711	0.672
	(0.260)	(1.417)	(43.197)	(0.615)	(5.183)	(0.367)	(0.199)
Mechanical Equipment	0.646	0.809	1.393	0.656	0.305	0.390	0.650
	(0.129)	(0.290)	(1.025)	(0.502)	(0.527)	(0.481)	(0.109)
Prec.-Weighted Average	0.720	0.754	0.338	0.310	0.451	0.502	0.578
	(0.063)	(0.094)	(0.114)	(0.102)	(0.278)	(0.086)	(0.038)

St andard errors in parentheses.
Regressions include the average growth of value added and of hours worked in the same industry in different countries.

Table 7 adds the average change in value added and in hours worked in the same industry in other countries as additional regressors to control for supply shocks. With these variables included, estimated elasticities differ more across countries: removing averages highlights national differences. All precision-weighted national averages of elasticities are significantly less than one. Germany continues to exhibit the highest average estimated elasticity at 0.754, closely followed by the U.S. at 0.720. The lowest precision-weighted national elasticity is for Belgium at 0.310. Such elasticities also suggest that labor productivity is procyclical after controlling for cross-national supply shocks.

[23]The much lower elasticities estimated for other European countries than Germany suggest that, as Abraham and Houseman note, their results may have been caused in part by the fact that Germany reports hours actually worked, while other countries instead report hours paid.

Table 8
Elasticity of Employment with Respect to Value Added, Controlling for Industry Effects

	USA	Deu	Fra	Bel	Nor	UK	Fin	Precision-Weighted Average
Food	0.851	0.029	-0.286	0.448	-0.126	-0.047	0.522	-0.035
	(1.286)	(0.247)	(0.182)	(0.777)	(0.725)	(0.326)	(0.321)	(0.120)
Textiles	0.756	0.459	0.413	0.508	-2.247	0.398	0.991	0.535
	(0.181)	(0.219)	(0.324)	(0.342)	(11.236)	(0.126)	(0.302)	(0.083)
Paper	0.338	0.307	0.336	-4.276	0.171	0.155	0.351	0.289
	(0.308)	(0.135)	(0.280)	(55.708)	(1.044)	(0.201)	(0.264)	(0.092)
Chemicals	0.685	1.861	3.062	0.185	-0.037	0.239	1.062	0.278
	(0.279)	(1.685)	(4.559)	(0.163)	(0.308)	(0.199)	(0.639)	(0.106)
Stone, Clay, and Glass	0.598	0.338	1.015	-0.223	0.649	0.244	0.577	0.511
	(0.065)	(0.165)	(0.612)	(0.385)	(0.934)	(0.142)	(0.157)	(0.052)
Basic Metals	0.391	-0.422	-8.933	0.490	0.775	0.473	-0.285	0.340
	(0.181)	(0.895)	(77.390)	(0.418)	(2.610)	(0.403)	(0.533)	(0.150)
Mechanical Equipment	0.597	0.332	0.664	0.063	4.957	0.287	0.177	0.442
	(0.145)	(0.177)	(0.404)	(0.455)	(39.745)	(0.224)	(0.877)	(0.095)
Prec.-Weighted Average	0.591	0.308	0.114	0.209	0.025	0.279	0.558	0.409
	(0.052)	(0.079)	(0.128)	(0.124)	(0.261)	(0.071)	(0.110)	(0.032)

St andard errors in parentheses.
Regressions include the average growth of value added and of employment in the same industry in different countries.
Sample 1970–84 for basic metals and mechanical equipment industries. Sample 1963–84 for other industries.

Table 8 reports national average coefficients from instrumental variables regressions of the elasticity not of man-hours but of employment with respect to value added, controlling for average growth of employment and value added in the same industry in other countries.[24] The U.S. has a markedly greater precision-weighted average estimated elasticity than most European countries: 0.591. For five of the six European countries the estimate is on the order of 0.3 or smaller: Finland is the exception.[25]

[24]Results are similar without the controls.
[25]The exception is Finland, with a average estimated elasticity of 0.559. One possible problem with this result is that changes average hours worked reflect not only the adjustment of hours worked by normally full time workers, but also changes in the proportion of full and part time workers. The result may simply show that in the U.S. part time work is more cyclical than in Europe and so average hours worked are less cyclical.

This is of interest: labor and job hoarding work to prevent layoffs, not necessarily to keep hours unchanged. The differing elasticities suggest that there may be some returns to pursuing institution-based explanations of procyclical productivity. The next section correlates the degree of procyclical productivity with unemployment. It argues that procyclical productivity is driven by institutional interactions of workers and firms, and not by technological interactions of workers and machines.

IV. Procyclical Productivity and the Unemployment Rate

The previous section establishes a presumption that a component of procyclical productivity is independent of supply-side shocks and is, instead, a consequence of shifts in demand. There are at least three interpretations of how such demand-driven procyclical productivity comes about. First, there may be increasing returns. Second, firms may hoard labor. Third, workers may hoard jobs.

Each interpretation leads to its own predictions of the likely cross-country pattern of procyclical productivity, and of the shifts over time in the cyclicality of productivity. "Job hoarding" by workers is likely to show itself most clearly in European countries, which have stronger labor movements and job protection legislation than the United States (see Cross, 1985; Bentolila and Bertola, 1990; Clark, 1988; and Lazear, 1990).

Section III above noted that the United States shows more adjustment of employment to shifts in demand than does Europe. It is difficult to see how increasing returns could produce such a pattern: European industry would have to have more sharply increasing returns than U.S. industry. It seems more straightforward to conclude that the European labor market has institutions that cause more labor hoarding, or job hoarding, than those of the United States.

The cross-country pattern alone does not tell us whether procyclical productivity arises because of hiring costs—firms hoarding workers because they fear they will not find personnel when the economy recovers—of because of firing costs—workers hoarding jobs because their positions in the labor market are valuable assets in which they have quasi-property rights.

Distinguishing Between Labor Hoarding and Job Hoarding

More information on the relative importance of labor hoarding, job hoarding, and increasing returns can be gained by looking at shifts in the cyclicality of labor productivity within each country. Increasing returns suggests no link between procyclical productivity and macroeconomic variables. But if labor hoarding is the cause of procyclical productivity, then productivity will be less cyclical in periods of high unemployment. In a time of high unemployment firms need not fear that workers will find new jobs and be unavailable when business picks up. Firms are therefore more likely to use temporary layoffs to manage their costs when the unemployment rate is chronically high.

By contrast, if workers resist layoffs—and "hoard" their jobs—because they are well organized or because of employment protection legislation, labor productivity will be more procyclical when unemployment is high. At a low unemployment rate quits will be sufficient for firms wishing to reduce work forces to do so by attrition. Unions are unlikely to spend political capital resisting layoffs when members can easily find other good jobs.

In the United States, labor productivity is less cyclical in unionized industries (Medoff, 1979; Freeman and Medoff, 1984). This suggests that labor hoarding is more important than job hoarding: if workers resisted layoffs, they would be more able to do so in highly unionized industries. If job hoarding were an important cause of U.S. procyclical productivity, labor productivity would be more cyclical in highly unionized industries. This cross-sectional pattern leads to the prediction that labor productivity will be less procyclical in the U.S. when the unemployment rate is chronically high.

By contrast, high unemployment should increase the procyclicality of productivity in Europe. In Europe, powerful union movements and legal restrictions on layoffs are likely to make job hoarding important. When unemployment is high workers are less likely to quit. And workers are more likely to resist layoffs when unemployment is high and makes their jobs valuable property.[26]

In either case, a significant effect of unemployment on the cyclicality of labor productivity is evidence that hiring and firing costs are among the causes of procyclical productivity. The absence of an effect would be evidence that the cause may be technological change, and increasing returns.

Estimating the Effect of Unemployment on the Procyclicality of Productivity

The interaction of value added growth and the unemployment rate was added to the independent variables of equation 1, giving equation 3:

$$(3)\quad \Delta\{\log(Y/N_{int})\} = c_{ni} + \beta_{ni}[\Delta\{\log(Y_{nt}-Y_{int})\}] + \gamma_{ni}[\Delta\{\log(Y/N_{i(-n)t})\}] + \mu[U_{n[t-\lambda]} - Avg(U_{nt})][\Delta\{\log(Y_{nt}-Y_{int})\} - Avg(\Delta\{\log(Y_{nt}-Y_{int})\})] + \varepsilon_{int}$$

where $U_{n[t-\lambda]}$ is the unemployment rate in nation n lagged λ years. We estimate equation 3 for λ equal to 1 and 2—with value added growth in the rest of manufacturing interacted with unemployment lagged one and two years. We lag unemployment one year to reduce correlations beween this period's disturbance and this period's unemployment rate. We lag unemployment two years for two reasons. First, since all data are averages over a year of continuous-time processes, a two-year lag is needed to completely purge the correlation with current disturbance terms.

[26]Just as anticipated future hiring costs may prevent layoffs during recessions, anticipated firing costs may reduce hiring during expansions. An extensive literature discusses the possibility that increased unemployment may have caused the constraints on layoffs in Europe to become binding (see Blanchard and Summers, 1986 and 1988; Bertola and Bentolila, 1990; Krugman, 1988; Freeman, 1988). It has been noted that aggregate employment and unemployment fluctuations have become more persistent in Europe in the 1980's (Blanchard and Summers). It is important to learn if this reflects greater persistence in demand fluctuations, or instead a reduced response of employment to demand fluctuations.

Second, use of unemployment lagged two years serves as a specification check: we believe that the degree of procyclical productivity changes relatively slowly, as workers' and firms' perceptions of the ease of finding new jobs or new workers shifts. If results differed depending on the exact lag of unemployment, we would no longer believe our specification.

Table 9
Interaction Coefficients of Value Added Growth and Unemployment, with Industry Value Added per Man-Hour as the Dependent Variable

	USA	Deu	Fra	Bel	Nor	UK	Europe-Pooled	Difference between USA and Europe-Pooled
Five Industries—Six Countries								
Unemployment	-0.104	0.173	-0.030	-0.055	0.092	0.024	0.022	0.127
Lagged 1 Year	(0.042)	(0.049)	(0.041)	(0.047)	(0.347)	(0.028)	(0.019)	(0.047)
Unemployment	-0.088	0.206	-0.039	-0.039	-0.025	0.048	0.033	0.121
Lagged 2 Years	(0.048)	(0.063)	(0.044)	(0.053)	(0.484)	(0.027)	(0.020)	(0.052)
Seven Industries—Four Countries								
Unemployment	-0.071	0.145			-0.270	0.049	0.077	0.148
Lagged 1 Year	(0.036)	(0.038)			(0.230)	(0.027)	(0.022)	(0.042)
Unemployment	-0.056	0.190			0.036	0.070	0.092	0.148
Lagged 2 years	(0.040)	(0.045)			(0.325)	(0.022)	(0.020)	(0.044)

In equation 3, averages are taken over 1963 - 1984, Average unemployment and rates of value added growth in the rest of manufacturing were subtracted in the second line of equation 3 to make the estimates of β and γ comparable to those estimated for equation 1 [27]. For each country, the system of equation 3 for the five industries food, textiles, paper, chemicals, and non-metallic minerals was estimated by seemingly-unrelated-regressions procedures, restricting μ to be the same across industries.[28] For those four nations with data available on employment in metals and equipment in the 1960's, the system was estimated for all seven industries as well, restricting μ to be the same across industries.

[27] This also reduces bias in estimates of μ caused by correlation between stochastic trends in unemployment and in productivity. Below we report estimates of μ whith the unemployment rate is included in the regression which indicate that any remaining bias is small.

[28] Similar results were obtained by estimating equation 3 by OLS for these industries, and for basic metals and mechanical equipment, and calculating the precision wieghted national average of the estimates of μ.

The first set of estimated μ interaction coefficients are presented in table 9. For each country-industry pair, it presents the values of the interaction coefficients from regressions of the growth of value added per hour worked on value added growth in other industries in that nation, the average of value added growth in the same industry in other nations, and the interaction of the unemployment rate level with national value added growth. For the United States the interaction term is negative and significant—a coefficient in the first line of -0.104 with a standard error of 0.042, although the coefficient is weaker in subsequent lines. This provides some evidence suggesting that labor hoarding is a dominant cause of U.S. procyclical productivity.

For Germany, the interaction is *positive* and significant, suggesting that job hoarding is a predominant cause of procyclical productivity and is more prevalent during period of chronically high unemployment. For Britain the interaction is positive, but its significance is borderline and changes from specification to specification.

For France and Belgium, the coefficient is negative and insignificant. For Norway, it is far from significant with a huge standard error, and its sign depends on the specification. The failure of a pattern to emerge for the small open economies of Norway and Belgium is not unexpected. The interaction term is only identified by the orthogonal nation-specific shock to aggregate demand, and these small open economies possess only small nation-specific movements in total manufacturing value added.[29] The failure of a pattern to emerge for France is disappointing, for France is large and has pursued independentmacroeconomic policies over the past third of a century. We expected to see stronger results.

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[29]The magnitude, however, of the Norwegian interaction coefficient is deserving of explanation. We tentatively ascribe the high magnitude to the fact that the Norwegian unemployment rate exhibits a very small rise in the 1970's, and is therefore highly collinear with a post-North Sea oil discovery dummy variable. Under this interpretation, the coefficient is capturing the fact that Norwegian productivity became much more sensitive to the level of production in Norway after the discovery of North Sea oil. If this interpretation is correct, the coefficient carries little information about the magnitude of "job hoarding" in Norway.

However, the difference between the interaction coefficients estimated for the United States and that estimated for a pooled sample of European countries is large and highly significant. Procylical productivity is weaker in the United States when unemployment is high, but it is not weaker in Europe. It is difficult to argue that the same "labor hoarding" that appears to generate procyclical productivity in the U.S. generates it in Europe as well.

Table 10
Interaction Coefficients of Value Added Growth and Unemployment, with Industry Value Added per Worker as the Dependent Variable

	USA	Deu	Fra	Bel	Nor	UK	Fin	Europe-Pooled	Difference between US & Europe-Pooled
Five Industries—Seven Countries									
Unemployment	-0.105	0.158	0.002	0.020	0.035	0.017	0.045	0.033	0.138
Lagged 1 Year	(0.048)	(0.054)	(0.037)	(0.043)	(0.312)	(0.030)	(0.052)	(0.018)	(0.051)
Unemployment	-0.099	0.093	-0.020	0.026	0.327	0.041	0.026	0.026	0.125
Lagged 2 Years	(0.054)	(0.072)	(0.040)	(0.048)	(0.438)	(0.031)	(0.065)	(0.020)	(0.057)
Seven Industries—Five Countries									
Unemployment	-0.075	0.144			-0.206	0.051	0.022	0.068	0.143
Lagged 1 Year	(0.037)	(0.045)			(0.225)	(0.026)	(0.041)	(0.026)	(0.045)
Unemployment	-0.069	0.083			0.365	0.067	0.017	0.073	0.142
Lagged 2 years	(0.041)	(0.059)			(0.308)	(0.023)	(0.051)	(0.020)	(0.045)

The dependent variable in equation 3 is production per man-hour. Since hiring and firing costs are likely to depend on the change not in man-hours but in employment, it is interesting to compare the behavior of production per worker with the behavior of production per man-hour.[30] Similarity in coefficients would suggest that table 9 is not simply due to changes in the labor force, or differences in the reporting of hours worked.

[30]Ideally, one would want to examine labor hoarding by examining hours worked by workers who normally work full time—thus obtaining a more direct measure of overtime and slack time hours. As noted above, differences between countries in the cyclicality of production per worker can reflect differences in the cyclicality of part time work. Changes over time within a country also reflect, among other things, the entry of women into the labor force.

Equation 3 was thus re-estimated replacing value added per man-hour by value added per worker. Table 10 reports the results, which are indeed similar to those reported in table 9. The procyclicality of value added per worker undergoes the same shifts with changing unemployment as does the procyclicality of value added per man hour. The interaction term is significantly negative only for the U.S, for which it is virtually unchanged: -0.105. For Germany, the coefficient is reduced to 0.158 from 0.173; for Britain the coefficient decreases to 0.017 in the first line of the table. The coefficients of Belgium, France, and Norway remain insignificant and negative.[31]

Errors in and Omissions of Variables

Controlling for average productivity growth in the same industry in different countries has the important advantage of controlling for supply shocks. But from a Keynesian standpoint it would be disturbing if results were substantially changed if the international average growth rates of value added in individual industries were excluded from the list of independent variables. It is also possible that the average of growth in the same industry in other countries is not an appropriate measure of supply and cost shocks: perhaps nation-specific shocks—like the discovery of North Sea oil—contaminate the variable the results for other countries. To the extent that nation-specific industry value added movements reflect the discovery of a nation-specific shocks like the discovery of North Sea oil for Norway, the average across nations of value added growth in an industry is a poor measure of true supply shocks.

These considerations led us to repeat the interaction regressions without controlling for average growth in the same industry in other countries, as shown in equation 4:

$$\text{(4)} \qquad \Delta\{\log(Y/N_{int})\} = c_{ni} + \beta_{ni}[\Delta\{\log(Y_{nt}-Y_{int})\}] + \mu[U_{n[t-\lambda]} - Avg(U_{nt})][\Delta\{\log(Y_{nt}-Y_{int})\} - Avg(\Delta\{\log(Y_{nt}-Y_{int})\})] + \varepsilon_{int}$$

[31]Finland can be included in regressions using value added per worker because average hours are not needed. Finland possesses a positive coefficient on the interaction term 0.093 with a standard error of 0.0483. The large standard error presumably reflects the difficulty of identifying national demand in a small open economy. The use of production per worker instead of production per man-

Except for Norway itself, the interaction terms were virtually unchanged, as table 11 shows.

Table 11
Interaction Coefficients of Value Added Growth and Unemployment, with Industry Value Added per Man-Hour as the Dependent Variable, No Industry Controls

	USA	Deu	Fra	Bel	Nor	UK	Europe-Pooled	Difference between USA and Europe-Pooled
Five Industries—Six Countries								
Unemployment	-0.122	0.139	-0.028	-0.009	-0.378	0.039	0.030	0.151
Lagged 1 Year	(0.042)	(0.057)	(0.054)	(0.041)	(0.376)	(0.029)	(0.020)	(0.047)
Unemployment	-0.115	0.168	-0.041	-0.002	-0.632	0.057	0.042	0.157
Lagged 2 Years	(0.047)	(0.072)	(0.058)	(0.047)	(0.530)	(0.026)	(0.020)	(0.051)
Seven Industries—Four Countries								
Unemployment	-0.090	0.087			-0.246	0.047	0.053	0.143
Lagged 1 Year	(0.035)	(0.049)			(0.238)	(0.027)	(0.024)	(0.042)
Unemployment	-0.083	0.124			-0.169	0.064	0.071	0.154
Lagged 2 years	(0.038)	(0.058)			(0.322)	(0.024)	(0.022)	(0.044)

Omitted variables might corrupt our results. Productivity might be more cyclical in Germany and Europe when unemployment is high simply because both the unemployment rate and the cyclicality of labor productivity have increased for other reasons. It is easy to see how the cyclicality of labor productivity could have a positive trend if, say, the ratio of administrative to production workers increases over time. Given the time pattern of European unemployment, the interaction terms in the regressions come close to comparing the cyclicality of labor productivity in the later half of to the cyclicality in the earlier half of the sample.

While the use of a disaggregated dependent variable—of sector-specific value added—gives greater precision, it does not increase the ability to discriminate between increased unemployment and the effect of time. In the case of the United States, the time pattern of unemployment makes it correlated with lagged oil shocks; lagged oil shocks might have reduced the cyclicality of labor productivity.

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hour reduces the spread of the European coefficients, making the contrast with the United States more striking.

In each case it is possible in principle to control for omitted variable bias by including an additional independent variable: the omitted variable interacted with the growth in manufacturing value added. But such regressions are likely to lack power.

We use an alternative procedure. If German unemployment is standing in for an omitted variable, this omitted variable should also have been in operation in other countries. If a secular increase in the amount of overhead labor is making productivity more procyclical and if the German unemployment rate is correlated with this omitted variable, than a regression of productivity growth in an *American* industry on the growth of value added in the rest of *American* manufacturing and the interaction with *German* unemployment should produce the same, positive, interaction coefficient.

Table 12
Interaction Coefficients of Value Added Growth and *German* Unemployment, with Industry Value Added per Man Hour as the Dependent Variable

	USA	Deu	Fra	Bel	Nor	UK	Europe-Pooled	Difference between USA and Europe-Pooled
Five Industries—Six Countries								
Unemployment Lagged 1 Year	-0.105 (0.029)	0.139 (0.057)	0.002 (0.062)	0.008 (0.073)	-0.058 (0.092)	0.064 (0.038)	0.052 (0.025)	0.157 (0.039)
Unemployment Lagged 2 Years	-0.122 (0.041)	0.168 (0.072)	0.047 (0.079)	0.033 (0.086)	-0.059 (0.114)	0.052 (0.038)	0.061 (0.028)	0.183 (0.049)
Seven Industries—Four Countries								
Unemployment Lagged 1 Year	-0.086 (0.024)	0.087 (0.049)			-0.042 (0.055)	0.067 (0.035)	0.049 (0.025)	0.134 (0.035)
Unemployment Lagged 2 years	-0.113 (0.032)	0.124 (0.058)			0.003 (0.066)	0.057 (0.035)	0.063 (0.028)	0.176 (0.042)

But table 12 shows that interacting the growth of manufacturing value added in a country with the *German* unemployment rate rather than the national unemployment does not cause the interaction terms to mimic the German pattern. The coefficient drops for England, remains negative for Norway, and for Belgium and France switches from negative to positive but remains insignificant.

These results do not suggest that the positive effect of German unemployment on the cyclicality of German labor productivity is due to the correlation of German unemployment and another factor causing increased cyclicality of labor productivity.[32]

One final errors-in-variables problem is somewhat subtle, but easy to evaluate. The decomposition of productivity growth into trend and cycle would be difficult even if many more years of data are available. The regressions reported above do not reveal whether the interaction term reflects a change in the cyclicality of productivity, or simply reflect changes in the trend in productivity growth which happen to be correlated with changes in the average decade-to-decade level of the unemployment rate. A confident interpretation of the coefficient on the interaction term would require many more years of data with high and with low unemployment. [33]

It is possible with available data to control for some obvious factors which could have changed both the trend of value added and of productivity. Inclusion of a time trend had very little effect; inclusion of the capital/labor ratio had little effect also (results not shown).

It is possible to control directly for changes in the trend of productivity and value added which happen to be correlated with decade-to-decade average unemployment levels by including unemployment itself in the regressions. Including the unemployment rate does not affect the interaction coefficients. As reported in table 13, the coefficient remains significantly negative in the U.S., and positive in Germany. The difference between pooled Europe and the U.S. remains large and significant.

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[32]The analogous question can be asked about the negative coefficients on the interaction term found for the United States: perhaps they reflect the fact that U.S. unemployment is highly correlated with lagged oil shocks. If so, regressions of other countries' productivity growth on the interaction of their growth of the rest of manufacturing and the *United States* unemployment rate should be negative.

However, when such regressions are estimated the interaction coefficient for Germany remains positive and significant (results not shown). The coefficient for England falls and is not significant, but remains positive. For other countries, coefficients remain insignificant and negative. The summary precision-weighted average coefficient on the interaction of *United States* unemployment and national rates of growth in the rest of manufacturing is positive; the opposite of what one would have expected according to the omitted variable-bias story.

[33]By removing the sample mean from the change in value added in manufacturing outside of industry I we have already attempted to avoid this problem while conserving degrees of freedom. The results reported in table 13 show that this was successful

Table 13
Interaction Coefficients with the Level of Unemployment Added to the List of Independent Variables

	USA	Deu	Fra	Bel	Nor	UK	Europe-Pooled	Difference between USA and Europe-Pooled
Five Industries—Six Countries								
Unemployment	-0.106	0.170	0.002	-0.061	0.127	0.021	0.035	0.142
Lagged 1 Year	(0.0410	(0.051)	(0.057)	(0.060)	(0.358)	(0.031)	(0.022)	(0.046)
Unemployment	-0.082	0.186	-0.033	-0.018	0.044	0.042	0.046	0.128
Lagged 2 Years	(0.049)	(0.067)	(0.066)	(0.077)	(0.497)	(0.033)	(0.026)	(0.055)
Seven Industries—Four Countries								
Unemployment	-0.065	0.138			-0.389	0.029	0.064	0.129
Lagged 1 Year	(0.035)	(0.040)			(0.246)	(0.030)	(0.024)	(0.043)
Unemployment	-0.052	0.162			0.164	0.064	0.085	0.136
Lagged 2 years	(0.040)	(0.047)			(0.335)	(0.024)	(0.022)	(0.046)

Assessment

None of the explorations and alternatives considered in the second half of this section shake the finding that the effect of unemployment on the cyclicality of productivity is different in the U.S. and in Europe. In the U.S., high unemployment is correlated with low cyclicality in productivity. This reinforces the cross-sectional evidence that labor hoarding by firms is an important component of procyclical productivity in the U.S. In Europe by contrast, the correlation between high unemployment and the cyclicality of labor productivity is positive or statistically insignificant. This suggest that the importance of job hoarding by workers is greater in Europe. This is as one would have expected from the literature on labor market institutions .

V. Conclusion

This paper has reported evidence that procyclical productivity is more than the consequence of supply-side shocks propagating through a standard real business cycle model. Such theories can account for a correlation of sectoral productivity growth with aggregate value added, and can—if cost shocks affect an intermediate input, like oil, necessary for production in many sectors—account for a correlation of sectoral productivity growth with aggregate productivity.

One explanation for procyclical productivity in response to shifts in demand uncorrelated with shifts in industry supply is that a firm receives surplus from keeping a stock of workers—and that a worker receives surplus from keeping an existing job. Thus labor "hoarding" by firms and job "hoarding" by workers underlies procyclical productivity. We have not built a model of the labor market. Nevertheless, the correlations make us optimistic about the utility of such models.

The differences across countries in the elasticities of labor input with respect to value added lend some support to the view that procyclical productivity reflects the strength of attachment of workers to jobs. In the United States, the response of employment to changes in value added appears much greater than in European countries. This difference might be caused by stronger union movements and employment protection legislation in Europe making "job hoarding" a more important factor in Europe. Real business cycle theories are silent on the causes of such cross-national differences.

Moreover, the *level* of the unemployment rate appears to have an effect on the degree to which productivity is procyclical. In the United States, higher unemployment levels correspond to significantly lower procyclicality. This might be explained in a model in which firms do not have to worry about permanently losing the ability to reemploy laid-off workers when unemployment is high. In Europe, however, increased unemployment does not seem to correspond to less procyclical labor productivity. British and German labor productivity appears more, not less, procyclical under high unemployment.

This difference between the effect of unemployment on the cyclicality of productivity might be accounted for by the greater ability of European workers to resist layoffs, and their determination to do so in times of high unemployment, in a model in which labor market institutions had effects on the organization and level of real production. By contrast, it is difficult to think how to begin to construct an explanation of this cross-Atlantic pattern based on supply shocks or on increasing returns to scale. The pattern suggests that it is worth investigating whether procyclical productivity arises from institutionally-influenced hiring and firing costs, and reflects the relationship between workers and firms—and not the relationship between workers and machines.

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Interpreting Procyclical Productivity: Evidence from a Cross-Nation Cross-Industry Panel

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